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VOLUME ISOMORPHISM IN THE SILICATES¹

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The recent demonstration, by the application of X-rays to the study of crystal structure, that the dimensions of atoms remain fairly constant and definite from one crystalline compound to another appears to necessitate a revision of the current views of isomorphism. To make this evident it is only necessary to list the volumes which atoms of some of the elements have been found by various workers (especially W. L. Bragg) to occupy, and, assuming crystals to be essentially close-packed structures, to consider the consequences of the relations brought out. The results of X-ray measurements are usually reported in terms of atomic diameters, but they may be transformed into volumes by using the approximate formula: $V = 4.2 (d/2)^3$, the unit becoming 10^{-24} cc. The elements vary in volume more or less—perhaps $\pm 30\%$ of the mean value—from one mode of combination to another. The mean values which seem most likely to be represented in the silicates, estimated from the data available, are given here in increasing order:

ELEMENT	VOLUME	EL.	VOL.	EL.	VOL.
O	1	Cr	10	Ca	22
F	$1\frac{1}{2}$	Fe	10	Na	23
C	2	Al	11	Sr	31
H	5	Ti	12	Ba	38
Cl	5	Mg	13	K	38
Be	7	Mn	14	Rb	47
Si	7	Li	15	Cs	55

¹ Read at the meeting of the Mineralogical Society of America, Ann Arbor, Michigan, Dec. 29, 1922. At this meeting Dr. H. S. Washington called attention to the fact that Professor F. Zambonini is working along similar lines. However, as his writings on the subject are not accessible to the writer, and as considerable interest was shown in the data, it has been decided to publish the paper as presented, with the understanding that in case it shall turn out that Professor Zambonini has already reached the same conclusions as to certain of the minerals, his claims to priority will not be questioned. Independent arrival at a given viewpoint enhances the probability of its essential correctness.

REQUISITES OF ISOMORPHISM.—It has long been held that in order to be able to replace one another, elements must be chemically analogous and of equal valence. The latter can only be regarded as applying, however, to elements while in the liquid or gaseous states; for there is good reason to believe that on entering the crystalline form, the valence of an atom may change completely. Sodium nitrate and calcium carbonate are isomorphous, even tho the valences of the constituents other than oxygen are, in the liquid state, dissimilar, for X-ray study shows that in the solid state sodium becomes homologous with calcium, and nitrogen with carbon. This and similar cases are best looked upon as representing what may be termed "double isomorphism" and symbolized in some such manner as: $[(\text{Na}, \text{Ca}) + (\text{N}, \text{C})]$.

It now seems more probable that the principal requisite of isomorphous replaceability is that the elements in question must possess approximately identical volumes, at least in simple compounds, the crystal structures of which represent fairly close packing of the constituent atoms. The principle of mass-isomorphism, the validity of which is emphasized by the present viewpoint, indicates, however, that the more complex the compound the more chances there are for readjustments to occur, and the greater the differences in volume of the mutually replacing atoms may be.

In this article it is proposed to discuss the application of this viewpoint to the interpretation of the compositions of certain silicates. Before taking up special groups of these it may be pointed out that the lack of isomorphism between carbonates and silicates, in spite of their presumably similar valence relations, has often been commented upon. The volume data furnish an adequate explanation, however, for carbon occupies less than one third as much space as silicon, and a structure which would be stable when including the one would be almost certain to become unstable should the other tend to enter.

THE FELDSPAR GROUP.—The chief peculiarities of the isomorphism in this group are (1) the limited replaceability of sodium and potassium, (2) the complete isomorphism of albite and anorthite, and (3) the isomorphism of the potassium mineral orthoclase with a barium compound in hyalophane or "baryta-

orthoclase." That these relations actually involve the molecules has been demonstrated by the X-ray studies of Hadding.²

An adequate reason for (1) is to be found in the decidedly dissimilar volumes occupied by the sodium and potassium atoms. Feature (2) has been fully discussed in a recent paper.³ The volumes of sodium and calcium are essentially identical, while the volume of aluminium is but slightly greater than that of silicon, so that double replacement $[(Ca,Na)+(Al,Si)]$ as required by the valence relations in solution, takes place. It is interesting to note that (3), the replaceability of potassium and barium is likewise based on their equality of volume. Analyses of barium-bearing feldspars show more or less parallel increase of silica and potash contents, indicating that here as in the plagioclases simultaneous replacement of aluminium and silicon occurs. The formulas of the end members of this series are, accordingly, $K(AlSi_3O_8)$ and $Ba(AlAlSi_2O_8)$ and the replacement is not " (Ba, K_2) " as often stated, but $[(Ba,K)+(Al,Si)]$.

LEUCITE GROUP.—The mineral analcite, usually formulated $Na(AlSi_2O_6) \cdot H_2O$ or $Na_2Al_2(SiO_3)_4 \cdot 2H_2O \cdot XH_2Si_2O_5$, is often included among the zeolites; in the opinion of the writer this is incorrect (as recognized in Doelter's *Handbuch der Mineral Chemie*) for a number of reasons, including the following: It occurs as a primary constituent of igneous rocks; it contains little water, and loses this before the blowpipe without the bubbling which the term "zeolite" implies; and it does not show the peculiar dehydration phenomena characteristic of most true zeolites, such as loss of H_2O below $100^\circ C$ and in several definite stages. Moreover it exhibits features and anomalies of crystallization which correspond closely to those of leucite, $K(AlSi_2O_6)$, and the one mineral can be transposed into the other at will by mere treatment with the hydroxide of the alternate alkali metal. The two minerals are accordingly regarded as belonging to one and the same group.

The striking fact that the potassium salt is anhydrous while the sodium salt contains water of crystallization is capable of adequate explanation on the basis of the volume relations. If the atoms in the crystals of leucite are closely packed, then when the smaller sodium atoms enter the same structure, gaps are left, and

² *Lunds Univ. Årsskrift*, N. F., [2], 17, No. 6, 26 pp., 1921.

³ *Am. Min.*, 7, 113, 1922.

a simple way for these gaps to be occupied is by water, which is present while the mineral is crystallizing. This seems unable to fill the gaps completely, however, and as shown by Foote and Bradley,⁴ in some cases hydrous albite or more probably silica enters. In others a hypothetical hydrous carnegieite (Parsons⁵) or perhaps mere natrolite is taken up. In such cases the solid solution is non-isomorphous and the agreement between the structures of the main compound and the dissolving ones need not be close. The replacement, then, is not merely (K, Na) but [K, (Na+H₂O+X)]. The formula of analcite may accordingly be written (Na+H₂O+X) (AlSi₂O₆).

PYROXENE GROUP.—Of the many cases of isomorphism in this group, the following may be selected for discussion: (1) The practically complete replaceability of Mg and Fe," but slight tendency of Ca to replace either; (2) the existence of lithium and sodium, but the lack of potassium pyroxenes; and (3) the improbability of the Tschermak molecule, R'' R'''₂SiO₆.

As to (1), it is easy to see a reason for the relations existing, for the volume of magnesium is closer to that of iron than to that of calcium. The lithium and sodium pyroxenes (2) are likewise readily accounted for. Starting from diopside, CaMg (Si₂O₆), the calcium atom is identical in volume with sodium, but the valence relations in the solutions require that this replacement be accompanied by the simultaneous entry of a trivalent atom. Both iron and aluminium approach magnesium in volume, so the exchange is easily consummated: the isomorphous replacement is [(Ca,Na)+(Mg,Al)] or [(Mg,Fe)], giving jadeite and acmite respectively. Lithium is distinctly smaller than sodium, and so, as in the case of entry of a small atom in place of a large one discussed under the preceding caption, gaps result from its occupation of the pyroxene structure. This time, however, the gaps are not filled by the entrance of water at the start, probably because they are too small. Instead, their presence makes itself manifest by the marked alterability of the resulting mineral, spodumene. The space required by the potassium atom, on the other hand, is evidently too great to permit this element to enter the pyroxene structure at all. (3) The Tschermak hypothetical molecule (Mg, Fe'') (Al, Fe''')₂(SiO₆) would be entirely possible

⁴ *Am. J. Sci.*, 33, 433, 1912.

⁵ *Univ. Toronto Studies, Geol. Series*, No. 14, p. 32, 1922.

from the valence viewpoint; but now that isomorphism is proving to be more a matter of volume than valence, the probability of its real existence requires attention. Starting from the formula of diopside-hedenbergite, $(\text{Mg,Fe}) \text{Ca}(\text{Si}_2\text{O}_6)$, the Tschermak molecule would represent the result of simultaneous replacement of (Ca,Al) (or $\text{Ca,Fe}'''$) and (Si,Al) . The first change corresponds to so marked a decrease in volume that the existence of the Tschermak molecule seems at least improbable. The excess alumina might, however, represent AlAlO_3 replacing MgSiO_3 , and fit the volume relations better.

AMPHIBOLE GROUP.—All that has been said concerning the pyroxenes applies with essentially equal force to the amphiboles. The amphibole structure appears to be less closely packed than the pyroxene, however, as the specific gravity is lower and a distinct amount of water is often taken up in solid solution, which presumably implies the filling of structural gaps.

BERYL GROUP.—The alkalis present in some occurrences of beryl are usually considered to represent the replacements (Be, Cs_2) , (Be, Li_2) , etc. The volume relations show rather definitely that these replacements cannot take place. The atoms of even the smallest alkali metal, lithium, are twice and of cesium many times as large as the beryllium atom. Inspection of the analyses shows, moreover, that the silica content decreases markedly as the alkali content rises, indicating that the presence of alkalis in beryl is connected with the entrance of a compound with different ratios, in some form of solid solution. This compound is not known among minerals, although plotting the SiO_2 against the alkali content shows it to be related to pollucite, and to have a composition approximating $\text{H}_2\text{O.Li}_2\text{O.Cs}_2\text{O.2Al}_2\text{O}_3.9\text{SiO}_2$.

NEPHELITE GROUP.—The potassium and sodium members of this group form an interesting analogy with those of the leucite group already considered, although the ultimate result is somewhat different. Admitting that the structure is reasonably closely packed when potassium is present, in kaliophillite, $\text{K(AlSiO}_4)$, the entrance of the less voluminous sodium to form nephelite, $\text{Na(AlSiO}_4) + \text{X}$, leaves gaps. Here instead of water + silica, only excess silica is taken up. This silica has been suggested⁶ to be present as (Si_3O_8) groups replacing (SiO_4) groups, but as shown in the paper on the plagioclases already cited, volume

⁶ By Clarke, Schaller and others.

relations in general do not fit in with such a replacement, and another interpretation seems called for. The excess silica may as well be considered "silica-of-crystallization," for the volumes indicate the formula of nephelite to be $(\text{Na} + \text{XSiO}_2) (\text{AlSiO}_4)$.

GARNET GROUP.—Isomorphism in the garnet group proper comprises the replacements $(\text{Mg}, \text{Ca}, \text{Mn}, \text{Fe}'')$ and $(\text{Al}, \text{Cr}, \text{Fe}''')$. The volumes of the trivalent metals here represented are all essentially identical. Among the bivalent ones, calcium is larger, and iron smaller, than the other two, but the differences are not great enough to prevent fairly complete mutual replacement. This group accordingly represents one of the best marked instances of isomorphism among minerals. Such gaps as exist, as that between pyrope and spessartite, appear to be of chemical rather than volume origin. Titanium, judging from its volume, should be able to replace the trivalent elements, but probably not more than in very slight degree the decidedly smaller silicon. The constitution of schorlomite therefore seems to require study by modern methods, before the formula assigned to it can be accepted in full. The fact that in the chrysolite group calcium is less isomorphous with other bivalent elements than they are among themselves accords with the volume relations.

SCAPOLITE GROUP.—The rather complex isomorphism represented in the scapolites corresponds to the volume relations in a striking way. The two end-members are meionite, $\text{Ca}_4(\text{Al}_6\text{Si}_6\text{O}_{25})$, and marialite, $\text{Na}_4(\text{Al}_3\text{Si}_9\text{O}_{24}\text{Cl})$, or sulfate or carbonate equivalents of the latter. The replacement of the four calciums of the first by four sodiums involves no volume change; the simultaneous replacement of three aluminiums by the slightly smaller silicons may leave some gaps in the structure, and the loss of one oxygen necessitated by the valence relations increases these. It is therefore to be expected that other elements or groups could find a place, and the entrance of chlorine, (HSO_4) and (HCO_3) is a natural consequence. If it were only possible to ascertain which of the analyses of vesuvianite recorded in the literature were not made on mixtures, its constitution could no doubt also be satisfactorily interpreted on the volume basis.

TOURMALINE GROUP.—The various replacements of atoms with one degree of valence by those with another which occur in this group, such as (Fe'', Li) and (Al, Mg) , correspond well with the volume relations. It is especially noteworthy that in spite of the

mass effect connected with the large size of the molecule, calcium seems unable to enter.

ZEOLITE GROUP.—Several of the minerals in this group have been regarded as illustrations of the replacements (Ca, Na_2) and $(\text{SiO}_4, \text{Si}_3\text{O}_8)$, which replacements, as pointed out in the paper on the plagioclases above cited, are from the volume viewpoint improbable even though the packing of the atoms in the zeolites is not very close, as the dehydration phenomena suggest to be the case. However, the analyses are open to other interpretations. In some zeolites there is a fairly good indication that the Ca and Na are present in definite proportions, as pointed out in Dana's System. That this is true of thomsonite can readily be seen if the silica content is plotted against the soda, as has been done in a paper presented in connection with this one.⁷ Allowing for a certain number of analyses having been made on mixtures, it seems true also of mesolite, stilbite, phillipsite (K instead of Na), etc.

The variable composition of chabazite has even been interpreted as due to two replacements, $(\text{SiO}_4, \text{Si}_3\text{O}_8)$ and (Ca, Na_2) , independently of one another. There is, however, no proof that the solid solution in chabazite is really of isomorphous type, and there may well be non-isomorphous solid solution of one or more of the associated zeolites.

MICA GROUP.—Analyses of some muscovites show a considerable excess of silica over that required by the normal formula, and a special varietal name, phengite, is applied to them. This has been interpreted as indicating the replaceability of SiO_4 and Si_3O_8 , but when the three variable constituents of the phengites in Dana's System, SiO_2 , Al_2O_3 , and $(\text{Mg}, \text{Fe})\text{O}$, are plotted in a triangular diagram, they range, not toward a mere "trisilicate," but toward a molecule with the composition $\text{H}_4\text{K}_2 (\text{Mg}, \text{Fe}) (\text{Al}_4\text{Si}_7\text{O}_{24})$. Comparing this with the normal muscovite formula $\text{H}_4\text{K}_2 (\text{Al}_6\text{Si}_6\text{O}_{24})$, it can be seen to represent the double isomorphous replacement $[(\text{Al}, \text{Mg}) + (\text{Al}, \text{Si})]$, the volume relations being adequately satisfied. The variability in composition of other micas, chlorites, etc., is in many if not all cases capable of interpretation in similar ways.

SUMMARY.—By applying to certain silicates the view that isomorphism is connected with volume rather than valence rela-

⁷ To be published in a subsequent number.

tions, it is possible to explain many of their peculiarities of composition in a simple manner as follows: In the feldspar group, the fact that the replaceability of potassium for sodium is limited, but for barium is more complete, the relation being one of double isomorphism, $[(Ba, K) + (Al, Si)]$; in the leucite group, the significance of the water in analcite, which is not a zeolite, the formula being $(Na + XH_2O + X) (AlSi_2O_6)$; in the pyroxene group, the lack of potassium members, and the improbability of the existence of the Tschermak molecule; in the beryl group, the presence of alkalies as due to solid solution of a pollucite-like substance; in the nephelite group, the probability that the excess silica is silica-of-crystallization, $(Na + XSiO_2) (AlSiO_4)$; in the garnet group, the extensive isomorphism; in the scapolite group, the homology of meionite and marialite, and the reason that sulfate and carbonate groups can enter; in the tourmaline group, the possibility of replacement of Li for Fe'' and Al for Mg; in the zeolite group, non-existence of (Ca, Na_2) and (SiO_4, Si_3O_8) replacements, and the explanation of variability as due to admixture or to non-isomorphism; and finally in the mica group the absence of evidence of (SiO_4, Si_3O_8) replacement, phengite approaching for instance $H_4K_2 (Mg, Fe) (Al_4Si_7O_{24})$, which represents double isomorphism $[(Al, Mg) + (Al, Si)]$.

NOTE ON LEUCHTENBERGITE FROM PHILIPSBURG, MONTANA¹

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A white chlorite occurring in metamorphosed limestones of the Philipsburg district of Montana was mentioned by Calkins² under the name leuchtenbergite. Several other white chlorites having been described since the publication of this paper, Mr. Calkins requested that his specimens, which were preserved in the National Museum, be reexamined. The chlorite has been analyzed in the museum laboratory, and the results of the analysis confirm the original identification, the mineral being a typical leuchtenbergite. The specimens examined are numbered P 480 in the type collection from the Philipsburg district. Since the

¹ Published by permission of the Secretary of the Smithsonian Institution.

² Calkins, F. C., *Geology and ore-deposits of the Philipsburg Quadrangle, Montana. U. S. Geol. Survey, Prof. Paper 78, 161, 1913.*

locality gives promise of furnishing leuchtenbergite in abundant finely crystallized specimens, the occurrence is directed to the attention of mineralogists by the following note.

The specimens were collected from the surface near Lost Creek, about 1 mile north of the Silver King Mine. The rocks of this locality are chiefly magnesian limestones which have undergone intense contact metamorphism and contain forsterite, spinel, and humite. They consist of medium grained pure white marble grading into a delicately greenish layer of fibrous appearance and silky luster to which the leuchtenbergite crystals are attached. This silky material is also largely calcite but its structure is determined by the presence of some fibrous silicate which could not be identified because its optical properties are obscured by the minutely intergrown calcite. It is also attacked when the calcite is dissolved by acid. It is probably wollastonite. The chlorite forms well developed tabular hexagonal crystals which reach an extreme diameter of 2.5 cm. with a maximum thickness of 5 mm. Over and around the crystals of leuchtenbergite is a layer of white calcite of flinty texture which is evidently a later deposit and which is easily removed. The chlorite varies from colorless to pale talc green, the luster on the basal (cleavage) plane being pearly while the other faces are dull. The hardness is about 3.5. The cleavage is micaceous and perfect, yielding flexible but inelastic plates. The optical properties as determined by Clarence S. Ross are as follows:—Biaxial, positive (+); $2V=6^{\circ}-14^{\circ}$ the variation being in part due to slight bending in splitting off plates for examination. Refractive indices, $\alpha=\beta=1.572\pm.003$, $\gamma=1.575$. Birefringence=.003.

ANALYSES OF LEUCHTENBERGITE

CONSTITUENT	1 PHILIPSBURG	2 ZLAToust	3 MAULEON
SiO ₂	31.44	30.80	32.10
Al ₂ O ₃	17.62	17.27	18.50
Fe ₂ O ₃	none	1.37
MgO	37.64	37.08	36.70
CaO	trace
FeO	trace
MnO	trace
H ₂ O (all above 110°C.)	13.19	12.30	12.10
Total	99.89	98.82	99.40

Upon analysis selected flakes free from impurities yielded the results given in column 1 of the following table. In columns 2 and 3 are given, for comparison, the analyses of leuchtenbergites from the original Zlatoust locality and from Mauleon.

The Montana material is free from all but a faint trace of iron. All of the water is basic being liberated only at a red heat. The above analysis yields the following ratios:

RATIOS OF LEUCHTENBERGITE FROM MONTANA

SiO ₂	.5214	17.38 x 3	.96 x 3
Al ₂ O ₃	.1724	17.24 x 1	.95 x 1
MgO	.9335	18.67 x 5	1.03 x 5
H ₂ O	.7328	18.32 x 4	1.01 x 4

These ratios indicate the usual formula, namely 5MgO.Al₂O₃.3SiO₂.4H₂O, or, as pointed out by Tschermak, one molecule of serpentine plus one of amesite. This interpretation was the foundation for Tschermak's interpretation of the chlorite group, for which he assumed serpentine to be one of the end members. Chemically leuchtenbergite would appear to support this conclusion. It is to be considered, however, that serpentine does not physically resemble the chlorites to any great extent, most of the foliated chlorite-like magnesian silicates having been found, upon investigation, to be talc. In this connection it may be instructive to compare the optical properties of the Montana leuchtenbergite with those of amesite, serpentine (antigorite), and talc as given by Larsen.³

OPTICAL PROPERTIES OF LEUCHTENBERGITE, ETC.

LEUCHTENBERGITE	AMESITE	SERPENTINE	TALC.
$\alpha = 1.572$	1.597	1.560	1.539
$\beta = 1.572$	1.597	1.570	1.589
$\gamma = 1.575$	1.612	1.571	1.589
Birefringence = .003	.015	.011	.050
2V = 6°—14°	0°	20°—90°	6°—30°
Sign (+)	(+)	(—)	(—)

The data available are inconclusive and the correct interpretation of this complicated group must await further investigation.

³ U. S. Geological Survey, Bull. 679, 1921.

THE GNOMONIC PROJECTION AS A MEANS OF IDENTIFYING CUT GEMS

F. S. WARTMAN AND F. N. GUILD, *University of Arizona*

The gnomonic projection developed mainly by Dr. Goldschmidt of Heidelberg has been found by many crystallographers to be the most satisfactory and entertaining method of investigating crystals. Graphic methods in the study of complex mathematical problems are being appreciated to a greater extent perhaps than formerly, and especially in the study of crystals have proved of inestimable value.

It occurred to the writers that a graph of the gnomonic projection of a cut gem would be a permanent and accurate record of the gem and might be used for the purpose of identification in cases of suspected falsification or substitution. A cut gem was therefore mounted on the two-circle goniometer and the values for ρ and ϕ recorded in the usual manner. The gem used was a white sapphire with thirty-three facets and the measurements were made without removing the stone from its setting in the ring. The gem was adjusted on the instrument solely by means of the "base" or top facet. This facet was made to read zero for ρ in all positions of ϕ . The gnomonic projection was then made on paper with the instrument designed by Goldschmidt for that purpose. The whole process required something like one and one-half hours. The most striking feature observed was that all of the facets are closer in towards the center than appears in a typical projection of a crystal. Natural pyramids are in general sharper than the facets cut on a gem. Probably the best method of comparing two or more graphs would be to superpose them using tracing paper. Owing to peculiarities mentioned above it would be well, also, to employ a radius of ten cm. instead of five as is customary in plotting. To facilitate the comparison radial lines are drawn from the centre to the face poles, the ordinary system of zone lines not being applicable to the artificially cut facets. Of course a further check is obtained by comparing values obtained for ϕ and ρ for each facet after due consideration for a zero meridian has been made. It might be noted that undue prominence has been given the top facet but this is necessary since adjustment of the gem on the goniometer could not be made by means of the pyramid or prism method. The

top face could be recut for purposes of masking identification and a new projection would be so dissimilar that comparison would be difficult. A slight recutting of this facet would not change the values of *phi* to any extent and those values could still be used in identification.

It is not believed that this will become a practical method of recording cut gems but it was thought worthy of brief mention. Occasion might arise where a record of this sort of some especially valuable gem would be of importance.

PROCEEDINGS OF SOCIETIES

THE PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences, December 14, 1922

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the Vice-president, Mr. Trudell, in the chair. Seventeen members and one visitor were present.

Upon favorable recommendation of the Council, Mr. Wilfred Broadbelt was elected an active member. Mr. Hoadley proposed Mr. Horace Hallowell for active membership. The chair announced the death of Mr. William R. Evans.

Dr. Edgar T. Wherry of the Bureau of Chemistry addressed the society on "Modern Views of Crystal Structure." The history of the study of crystal structure was reviewed, introductory to a description of the Laue, Bragg, and Hull methods of X-ray analysis, and some of the results achieved. A *domain* was defined as the space through which the attractive and repulsive forces of the atom are effective. The shape of the domains may be derived from the space lattices, which are determined by the equilibrium of these forces. The packing of domains was illustrated with a number of models and lantern slides. Crystal habit was regarded by the speaker as being principally influenced by impurities in the solution, but the faster the formation of the crystals, the less the influence of the impurities. Isomorphism is limited to atoms that approximate each other in size; thus, there is limited replacement of K for Na, while that of K for Ba is complete, as illustrated by the feldspars. The alkalis, Cs, Rb, and Li in the beryl group are considered to be due to an isomorphous *hexagonal* pollucite. In tourmaline Li replaces ferrous iron. Other cases of atomic isomorphism in the micas, pyroxenes, scapolites, and zeolites were cited. A vote of thanks was accorded the speaker for his interesting and instructive communication.

SAMUEL G. GORDON, *Secretary*

BOOK REVIEWS

THE MINERALOGY OF PENNSYLVANIA. SAMUEL G. GORDON. Special Publication No. 1, Acad. Nat. Sci. Phila., 1922. Price \$3.75.

The frontispiece of this valuable work is an illustration of pyrite crystals from French Creek, which will preserve for all time the exact outlines and appearance of these remarkable crystals.

The Introduction (Chap. I) gives an excellent historical outline from the time of the beginning of the development of mineralogy in Pennsylvania to the present time, together with an outline of the scope of the present paper. Chapter II, on the Origin and Occurrence of Minerals, is a new and interesting departure; it deals with them as natural chemical compounds whose formation is governed by well known physico-chemical laws. The detailed classification is made on the basis of mineral assemblages, which are divided into two classes, i.e., those arising from magmatic phenomena, and those formed by sedimentary processes. The minerals forming the assemblages are classified as primary, metamorphic, or weathering products. Under igneous rocks are considered the silicic, alkalic, calcic, and magnesian types, with special attention to the pegmatites and hydrothermal deposits; among the sediments, the silicious, argillaceous, calcareous, magnesian, ferruginous, etc., and carbonaceous deposits are taken up, with detailed enumeration of the most typical minerals in each.

Chapter III gives a résumé of the general geology of Pennsylvania, by physiographic divisions, with further subdivision into counties for convenience. Chapter IV, the Descriptive Mineralogy of Pennsylvania, considers the minerals arranged by species in the Dana classification, with the Pennsylvania localities listed under each. A large number of figures gathered from the literature are given; chemical analyses are abundantly represented. Chapter V gives the list of mineral localities of Pennsylvania arranged alphabetically, with species reported from each, the authority and date, and the exact location of the occurrence, expressed numerically according to the Ninth Coördinate System of J. F. Kemp, explained on page 9 of the introduction. A bibliography and an index of localities and species close the volume.

This is a full and authoritative compilation of all available data on a classic area, and as such, as well as for the original methods of classification presented, it deserves an important place in any complete mineralogical library. A. C. H.

DAS FEINBAULICHE WESEN DER MATERIE NACH DEM VORBILDE DER KRISTALLE. FRIEDRICH RINNE. Second and third editions. 8-vo. 168 pages, with 9 plates and 203 figures. Borntraeger Brothers, Berlin, 1922.

The reception of the first edition of this volume, entitled *Die Kristalle als Vorbilder des feinbaulichen Wesens der Materie*, which was published in 1921 (*Am. Min.* 7, 161, 1922), was so enthusiastic and widespread as to call for a revised and enlarged edition within a year. Sixty-seven pages, including an index, four full-page plates, and 103 figures have been added. The book gives an excellent review of the great strides made in our knowledge of the structure of matter, especially from the standpoint of the crystallographer. While the treatment is on the whole the same as in the earlier edition, it is somewhat more historical. An English translation will undoubtedly be greatly welcomed by those who experience difficulty in reading German with ease. It has already been translated into several foreign languages.

EDWARD H. KRAUS

NOTES AND NEWS

On page 90 of Whitlock's List of New Crystal Forms of Minerals (*Am. Min.* 7, 193, 1922) occurs the remark "...the writer is keenly conscious of the possibility of omissions and errors, and will gratefully welcome additions and corrections."

Critical examination of the work indicates that as in all such compilations there are a certain number of errors. In order to warn crystallographers not to depend on the data too implicitly, it seems desirable that some indication as to their nature and frequency be published.

Some of the errors are mere typographical ones such as are almost unavoidable in technical matter and are too obvious to require separate mention; here we would include the misspelling of at least 16 mineral names, 50 locality names and 100 author's names.

There are, however, more serious errors in the transcribing of the crystallographic data. Thus, selecting at random 10 pages, (184-193) the original articles were consulted and at least 25 such errors noted as: omission of letters (pp. 184, 188); wrong letters, as *v* for 032 of lautite (p. 187), *x* for $\bar{2}21$ of leadhillite (p. 189) σ for $\bar{4}36$ of same; erroneous symbols, as for krennerite (p. 185) 58 581 instead of $5/2$ 4 582, laurionite (p. 187) 2 221 instead of $\frac{1}{2}1$ 122, lorandite (p. 192) 05/4 054 instead of 04/5 045, and several others; entire omission of new forms as for kröhnkite (p. 185) $m\infty$ 110, for lautite (p. 187) w $\frac{1}{2}1$ 122, and for lawsonite (p. 188) b 0 ∞ 010; insertion of several forms as new already in Goldschmidt's list, and errors in signs, and in other details. To be sure, crystallographers making an intensive study of a mineral are accustomed to look up the original in any case, and so can discover these errors; but most unfortunately, the references are at times erroneously given, making it hard to locate the articles wanted; on p. 194 an article is ascribed to vol. VII of this journal, whereas IV is meant; and on p. 222 a similar error is made in one of the author's own articles; while other journals fare no better.

Finally there are a considerable number of minerals omitted, altho their crystallographic data were published during the period covered. The following twenty were noted: barylite, betafite, bischofite, cabrerite, catoptrite, chalcolamprite, derbylite, flokite, (=tilolite), samarskite, sarkinite, lacroixite, loranskite, losenite, mesolite, neotantalite, orientite, otavite, rhodizite, tephroite, and tantalum.

W. T. S., H. W. T., E. T. W.

At the anniversary meeting of the Royal Society, the Copley medal was awarded to Sir Ernest Rutherford for his researches in radioactivity and atomic structure.

It is announced by the United States Geological Survey that the price of radium has decreased owing to the discovery of radium bearing ores in Africa, which are easily worked at a much lower cost than the American mines. This caused a drop from \$120,000 a gram to \$70,000, which is the lowest price at any time since radium has been used.

Joseph W. Grieg, formerly assistant in the department of mineralogy at Columbia University, has been added to the staff of the Geophysical Laboratory, Carnegie Institution of Washington, as a petrologist.

The Academy of Natural Sciences of Philadelphia announces the selection of Professor Alfred Lacroix, president of the Geological Society of France, as the recipient of the "Hayden Memorial Geological Award" for 1923. This award was created by a deed of trust made with the academy, on April 11, 1888, by Mrs. Emma W. Hayden, "as a reward for the best publication, exploration, discovery or research in the sciences of geology and paleontology."

The next annual meeting of the Mineralogical Society of America will be held at Washington, D. C., December 27-29, in conjunction with that of the Geological Society of America.

We regret to note the death of Dr. William S. Disbrow of Newark, New Jersey. He was one of the founders of the Academy of Medicine of Northern New Jersey and a collector of minerals and antiques.

NEW MINERALS

Larsen's "Microscopic identification of the non-opaque minerals," reviewed in this Journal, *Am. Min.*, 7, 69, 1922, contains a considerable amount of data on mineral species, near-species, and varieties which seems likely to introduce changes in ranking in a number of cases. While final action on these may have to await consideration by the Committee on Nomenclature and Classification of the Mineralogical Society of America, important changes not already published or abstracted in our pages may be enumerated here.

In Larsen's "New Data," pages 34 to 160, there are 32 cases where the optical properties of supposed varietal minerals seem sufficiently distinct from those of the related species to suggest the desirability of raising these to sub-species, and in some cases to full species, rank. These comprise:

Alurgite	Jeffersonite
Antlerite	Kalinite (fibrous form)
Auerlite	Mariposite
Brandisite	Melanophlogite
Coeruleolactite	Paraffin
Cookeite	Picotite
Corkite	Pleonaste
Cuprodescloizite	Ripidolite
Destinezite	Salmoite (entirely new)
Endlichite	Schneebergite
Ferberite	Schroëckingerite
Ferrocolumbite	Serpentine (chrysotile form)
Fuchsité	Uraconite
Griphite	Uranochalcite
Heterolite	Voelckerite
Heterosite	Zippeite

On the other hand, specimens labeled as representing supposed species show features which in a number of cases suggest other interpretations, as follows:

Castanite, apparently identical with quetenite.

Cervantite, varies widely and is evidently made up of more than one species.

Dawsonite, comprises more than one species.

Dufrenite, shows wide variation, and may be composite.

Guarinite, does not agree with previous data, and shows peculiar features.

Hibbenite, seems optically identical with alpha-hopeite.

Ihleite, seems essentially identical with copiapite.

Janosite, seems also identical with copiapite.

Johannite, is usually another species, and is doubtfully distinct.

Kalinite, comprises two species, and it is recommended that the name be limited to the fibrous, strongly birefringent form, the other to be called potash alum.

Knoxvillite, seems identical with copiapite.

Litharge. In announcing the recognition of two forms of lead monoxide, Larsen had suggested the name litharge for the yellow, orthorhombic form, and massicot for the red, tetragonal one. The common usage for the artificial products, as well as Dana's statements under the species massicot, suggest that this be reversed.

Lithargite. The mineralogical form of the name, preferred in this journal. Now to be defined as the red tetragonal form of PbO.

Massicot. Discussed under litharge.

Massicotite, the mineralogical form of the name, preferred in this journal.

To be defined, following Dana, as the yellow orthorhombic form of PbO. Metavoltaite, a new spelling of "metavoltine."

Montmorillonite, is variable and needs further study.

Pseudomalachite, seems identical with dihydrite.

Psittacinite, seems identical with cuprodescloizite.

Pyrrhite, may be grouped with koppite as a sub-species.

Quenstedtite, seems identical with copiapite.

Rivaite, "not very different from . . . wollastonite." (Compare Bowen, *Am. Min.* 7, 64, 1922.)

Scorodite, in 8 specimens showed at least 4 different sets of properties and may represent as many species.

Stibiconite, varies widely and like cervantite is evidently composite.

Utahite, seems identical with jarosite.

E. T. W.

ABSTRACTS—MINERALOGY

A NEW DESCRIPTION OF AMESITE. EARL V. SHANNON. *Am. J. Sci.*, 49, 96-8, 1920.

Amesite from Chester, Mass. is bluish-green in color, pearly to metallic in luster, and translucent to opaque except in thin fragments. Micaceous basal cleavage, laminae are brittle. H. 2.3, sp-gr. 2.77. Optical properties: biaxial, 2V very small, Bx_d normal to perfect cleavage, +, colorless, α 1.597, β 1.597, γ 1.612, all \pm 0.003. Analysis: SiO_2 20.95, Al_2O_3 35.21, FeO 8.28, CaO 0.58, MgO 22.88, MnO trace, H_2O -0.23, H_2O +13.02, sum 101.15. Formula: $2(Fe, Mg) O.Al_2O_3.SiO_2.2H_2O$.
E. F. H.

IMMERSION METHOD FOR THE DETERMINATION OF INDICES OF REFRACTION OF SOLID BODIES. CH. FABRY. *J. de Phys.*, 9, 11, 1919; through *Am. J. Sci.* 49, 148-50, 1920. NOTE. H. S. UHLER. *Am. J. Sci.* 49, 143-5, 1920.

Fabry's method allows the det'n of n to the fifth decimal, and exact equality of indices of the unknown and the immersion liquid is unnecessary. A goniometer,

set of standard glass prisms, series of immersion liquids, and an immersion trough are used. A light ray passes through liquid, prism, and unknown. The method involves the finding of values of the angular deviation of the telescope and linear displacement of the ocular for several liquids of near values of n , which must approximate that of the unknown. The value of deviation which would have been observed had the n 's of liquid and unknown been equal is obtained from a graph. A formula is given for the calculation of the n of the liquid (and that of the unknown). A more general formula and proof are given in Uhler's note.

E. F. H.

THE OCCURRENCE OF DYSCRASITE IN AUSTRALIA. GEO. SMITH. *Am. J. Sci.*, **49**, 278-80, 1920.

Dyscrasite has been found in the Consols Mine, Broken Hill, in large amount. Very fine arborescent crystallizations were encountered. Crystals in calcite were unterminating, prismatic; occasionally pseudo-hexagonal plates. The forms $c(001)$, $c(011)$, $s(112)$, and $s(133)$ were identified.

E. F. H.

APHTHALITE (GLASERITE) FROM SEARLES LAKE, CALIF. W. F. FOSHAG. *Am. J. Sci.*, **49**, 367-8, 1920.

This mineral was found in a well boring. It occurred in small trigonal crystals, with c and r . Optical properties: uniaxial, +, $\omega=1.490$, $\epsilon=1.496$, both ± 0.003 . Analysis: K 32.46, Na 9.01, SO_4 53.71, Cl 4.76, H_2O 0.10, sum 100.04.

E. F. H.

NEW MINERAL NAMES. W. E. FORD. *Am. J. Sci.*, **49**, 452-3, 1920.

The following are briefly described:—bäckströmite, bismutoplagonite, cocin-
erite, echellite, ferrazite, gavite, manganfayalite, oruetite, pyrobelonite, sobralite,
sphenomanganite, and villamaninite.

E. F. H.

CONTRIBUTIONS TO CHEMICAL PETROGRAPHY. III, with an appendix. A. OSANN. vii+347 pp.; Leipzig, 1916; thru *Mineralog. Abstr.* **1**, 399.

The appendix gives 236 analyses of rock-forming minerals (micas, amphiboles, pyroxenes, and garnets), previously published.

E. F. H.

OPTICAL PROPERTIES OF ANTHOPHYLLITE. N. L. BOWEN. *J. Wash. Acad. Sci.*, **10**, 411-4, 1920.

A new det'n on anthophyllite from Franklin, N. C. gives: α 1.6195, β 1.6301, γ 1.6404; $2V$ $88^\circ 46'$. $FeO+MnO$ 10.70, MgO 28.69. Pure (artificial) Mg -amphibole (kupferrite) had α 1.584, γ 1.597.

E. F. H.

THE NOMENCLATURE AND CLASSIFICATION OF SULFIDE MINERALS. EDGAR T. WHERRY. *J. Wash. Acad. Sci.*, **10**, 487-96, 1920.

In this classification, with the sulfides are ranged all analogous compounds such as selenides, etc., oxysulfides, nitrides, phosphides, carbides, and silicides. These are separated on the basis of metallic or non-metallic character of the more basic element concerned; then into chemical divisions depending on the ratio of basic to acidic elements present. A final sub-division into groups is made on crystallographic considerations. A consistent nomenclature is used thruout the classification.

E. F. H.

THE COLORS OF COLLOIDS. WILDER D. BANCROFT. *J. Phys. Chem.*, **22**, 601-30, 1918, (I); **23**, 1-35 (II); 154-85 (III); 253-82 (IV); 289-347, (V); 356-61, (VI); 365-414, (VII); 445-68, (VIII); 554-71, (IX); 603-33, (X); 1919.

Of especial interest to mineralogists are: I, Introduction; II, Reflection and refraction; IV, Interference and diffraction; V, Metallic and vitreous lustre; VIII, Metallic colors; IX, Colloidal metals; X, Glasses and glazes. E. F. H.

AN UNUSUAL DEPOSIT OF ARAGONITE FROM SEA-WATER. ROGER C. WELLS. *J. Wash. Acad. Sci.*, **10**, 249-54, 1920.

Small prismatic crystals formed in sea-water which had remained sealed in a glass tube since 1913, were identified as aragonite. The conditions of formation are discussed. E. F. H.

SUBSTITUTES FOR PLATINUM IN BEAD AND FLAME TESTS. C. C. KIPPLINGER. *J. Ind. Eng. Chem.*, **12**, 500, 1920.

Bead tests are made on a rod of graphite. For flame tests a paper wick is inserted in an elbow-shaped glass tube containing the solution to be tested, and this wick is burned. E. F. H.

NOTE ON THE COLORING AND THERMOLUMINESCENCE OF GLASS PRODUCED BY RADIUM RADIATION. S. C. LIND. *J. Phys. Chem.*, **24**, 437-48, 1920.

The literature is summarized. It is pointed out that thermoluminescence of radiated glass and the discharge of the induced color are not always simultaneous phenomena. In violet colored glass or silica the thermoluminescence can be produced at temps. well below 200°, while the loss of color occurs above 500°. E. F. H.

SOME CHEMICAL OBSERVATIONS ON THE VOLCANIC EMANATIONS AND INCRUSTATIONS IN THE VALLEY OF 10,000 SMOKES, KATMAI, ALASKA. J. W. SHIPLEY. *Am. J. Sci.*, **50**, 141-53, 1920.

The following minerals were formed by the action of volcanic gases (H_2O , SO_3 , HCl , HF , H_2S , SO_2 , NH_4) on pumice and ash on the valley floor:—sulfur (paramorphs of orthorhombic after monoclinic xls.), arsenic sulfides, corundum (action of HF or NH_4F on Al_2O_3), amorphous silica (decomposition of SiF_4), gypsum, halite, alum, anhydrite, Fe chlorides, Fe sulfates, magnetite, amorphous Fe_2O_3 , vivianite, and pyrite crystals. E. F. H.

AN OCCURRENCE OF NAUMANNITE IN IDAHO. EARL V. SHANNON. *Am. J. Sci.*, **50**, 390-1, 1920.

This first U. S. locality is at the DeLamar mine, Owyhee Co., Idaho. The mineral is dark blue-grey, markedly sectile, and malleable. H. 2.5, sp. gr. 6.527. Analysis after deducting impurities: Ag 75.98, Se 22.92, S 1.10, sum 100.00. Pb, Cu, Au, Zn, Bi, Sb, As, and Te are absent. E. F. H.

SULPHOHALITE FROM SEARLES LAKE, CALIF. WM. FOSHAG. *Am. J. Sci.*, **49**, 76-7, 1920.

The n of sulphohalite is 1.455. Many so-called octahedral halites, if closely examined, may prove to be this mineral. E. F. H.